arctic health research center

NORTH POLE GROUNDWATER STUDY

REPORT NO. 105

EALTH, EDUCATION AND WELFARE
TROL ADMINISTRATION

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Environmental Engineering Section
Arctic Health Research Center
Environmental Control Administration, Public Health Service
U. S. Department of Health, Education, and Welfare
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I. INTRODUCTION

On May 12, 1965, the Environmental Engineering Section of the Arctic Health Research Center received written permission from the mayor and city council of North Pole, Alaska, to initiate a study of groundwater pollution in that city. The purpose of the study was to determine the effect of private waste disposal systems (primarily septic tanks) on the quality and sanitary condition of the individual water supplies in the area.

II. BACKGROUND

North Pole is located approximately 14 miles south of Fairbanks. For several years its well waters have been considered by local residents to be of dubious quality. Public health personnel at Eielson Air Force Base have, on several occasions, closed rentals in the city to military personnel because of unsafe well water. There have been several suspected instances of viral epidemics, including infectious hepatitis.

North Pole has no central sewer or water system and each dwelling supplies its own water from shallow wells located in soils which undergo deep seasonal frosts. Of some 100 wells in the city, all but five are between 15 to 30 feet deep. Those examined yielded a water of very undesirable character. High iron content, foaming, and unpleasant odors are the most common complaints from the local population, who consequently haul their drinking water from the city of Fairbanks or from the military bases, all of which have water treatment

facilities. Several houses have installed water softeners, and in some cases, chlorinators; but the occupants still place little confidence in the quality of their water.

Sewage treatment is accomplished almost exclusively by private, single-dwelli septic tanks, which discharge their effluent into the ground. The high ground water table in the area, sometimes less than six feet, suggests that this efflue mixes with the groundwater. This, and the suspicion that the 50-foot minimur separation between a septic tank effluent and a water well may not be maintaine in all cases, create a very questionable sanitary condition.

By March 5, 1966, permission was obtained from the property owners along Fifth Street to enter their property and homes to obtain water samples, install any equipment needed in the study, and to inject fluorescent dye into septic tan effluents in an attempt to trace their paths through the aquifier.

III. COLLECTION OF DATA

Synthetic detergents and bacteria of fecal origin were considered to be the key indicators of the presence of sewage in the well waters. These pollutants woul pass through the septic tanks of the area and enter the groundwater through the leaching fields.

Water samples for bacterial and chemical analysis were obtained from the hous selected for the study on a bi-monthly schedule. Cold water samples were take in all cases, and where applicable, before water softening. After allowing the ta to run for several minutes to clean the line, samples were collected in polyethy-lene bottles for chemical analysis. After sterilizing the faucet with an alcohol burner, water for biological testing was collected in sterilized glass bottles.

After an initial period of more extensive analysis to obtain general water quality characteristics, samples were routinely analyzed for synthetic detergents, hardness, alkalinity, iron, and pH. Originally, the presence of detergents was determined by the analysis for alkylbenzene sulfonate (ABS); later this determination was made by the analysis for linear alkylate sulfonate (LAS), the more biodegradable surfactant now used by the soap and detergent industry. The twelfth edition of the American Public Health Association's Standard Methods for the Examination of Water and Wastewater was followed for all chemical analyses. The bacterial content of the water was determined by tests for the presence of coliform and fecal streptococcus organisms, made immediately upon arrival at the laboratory, using the membrane filter technique.

To monitor seasonal groundwater activity, a stage recorder was installed in a house located in the ground behind the Santa Claus House; home and business of the North Pole Mayor. The recorder, operated by a manually-wound, eight-day clock, charted groundwater fluctuations. To protect the recorder from severe winter temperatures, an insulated plywood box was erected in the well house, and a 50-watt bulb placed in the box. A heat lamp, operated by a timer, was installed inside the well casing to prevent the water surface in the well from freezing around the float wire and giving erroneous groundwater level data. Electricity for the timer was provided from the Mayor's dwelling.

IV. DISCUSSION OF FIRST YEAR RESULTS

It was difficult to maintain a regular sampling schedule because residents were not always at home on the days samples were collected. Therefore, emphasis in the latter part of the study was on those homes with the highest incidence of pollution and for which sampling records were most complete. The results of

one year's samples from four typical dwellings, "A, B, C, and D," appear in the Appendix.

The sampling showed the water to be of poor quality. In most cases the natura[l] character of the water, with its high hardness and extremely high iron and man-ganese content, makes it undesirable for human consumption. Iron and man-ganese are undesirable for esthetic and economic reasons. They impart a brownish color to water which stains laundry and plumbing fixtures and impairs the taste of beverages. Both were detected in concentrations above the U. S. Public Health Service's recommended limit of 0.3 mg/l for iron and 0.05 mg/l for manganese. The presence of synthetic detergents was also detected in con-centrations well above the recommended limit of 0.5 mg/l for drinking water. In several instances bacteria were present in the water.

In most cases the water samples showed a wide variation in their characteris-tics; but as noted in Figures 2 and 3 no relationship was demonstrated between the character of the water and the groundwater fluctuations shown in Figure 1. However, the continual presence of synthetic detergents and an occasional posi-tive coliform test indicated that septic tank pollution of the groundwater supply was occurring.

The scarcity of coliform organisms is not unexpected in this situation for sev-eral reasons. Studies (2) have shown that in some sandy soils, coliform organ-isms travel much more slowly than synthetic detergents and do not penetrate much beyond 6 feet in 417 days. When the flow velocity was doubled to 0.8 ft/day, the arrival time at a four-foot distance was only reduced from 144 to 82 days.

In addition, groundwater in the area possessed a characteristically high iron content. There is the possibility that this high iron content interferes with the growth of sheen-producing colonies which are required for positive coliform tests. Research performed in our laboratory using membrane filter techniques indicates that as iron concentration in a solution of known bacterial concentration is increased, the number of colonies appearing on the filters after incubation decreases. If that be the case, the negative coliform counts do not rule out fecal contamination.

In an effort to confirm that sewage effluent was finding its way into the drinking water, fluorescent dye was introduced into the effluent of one septic tank, and water samples analyzed for presence of the dye using a fluorometer. The samples were allowed to stand overnight to permit the iron in the water to settle out thereby eliminating effects of turbidity on this procedure. Although there were a few instances of detectable color, in most cases dye was not present in the well water.

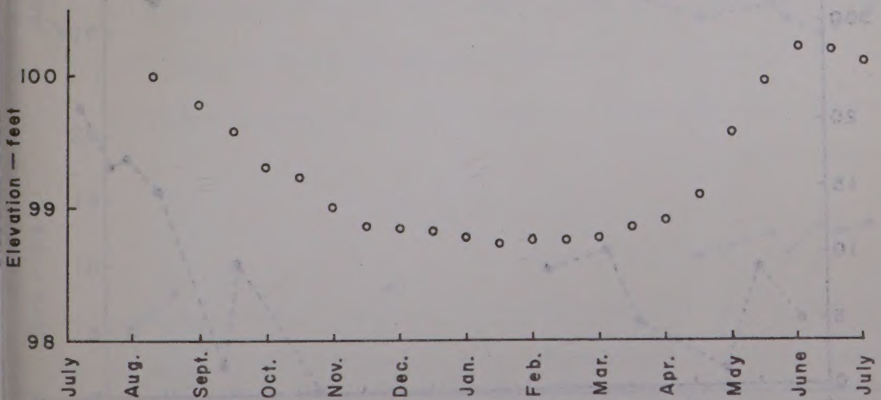

Figure 1 - Groundwater level fluctuations - North Pole, Alaska 1966-67.

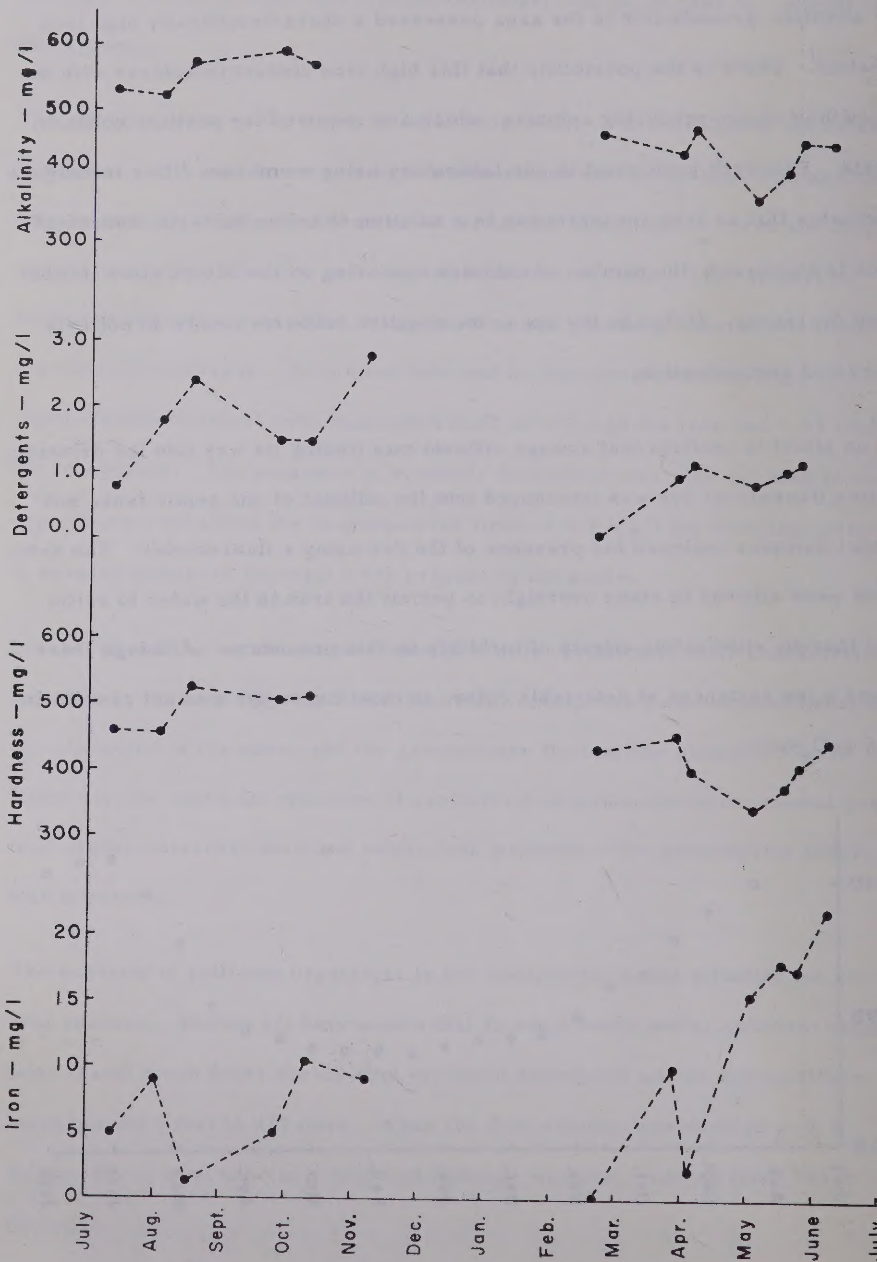

Figure 2 - Analytical data from House B.

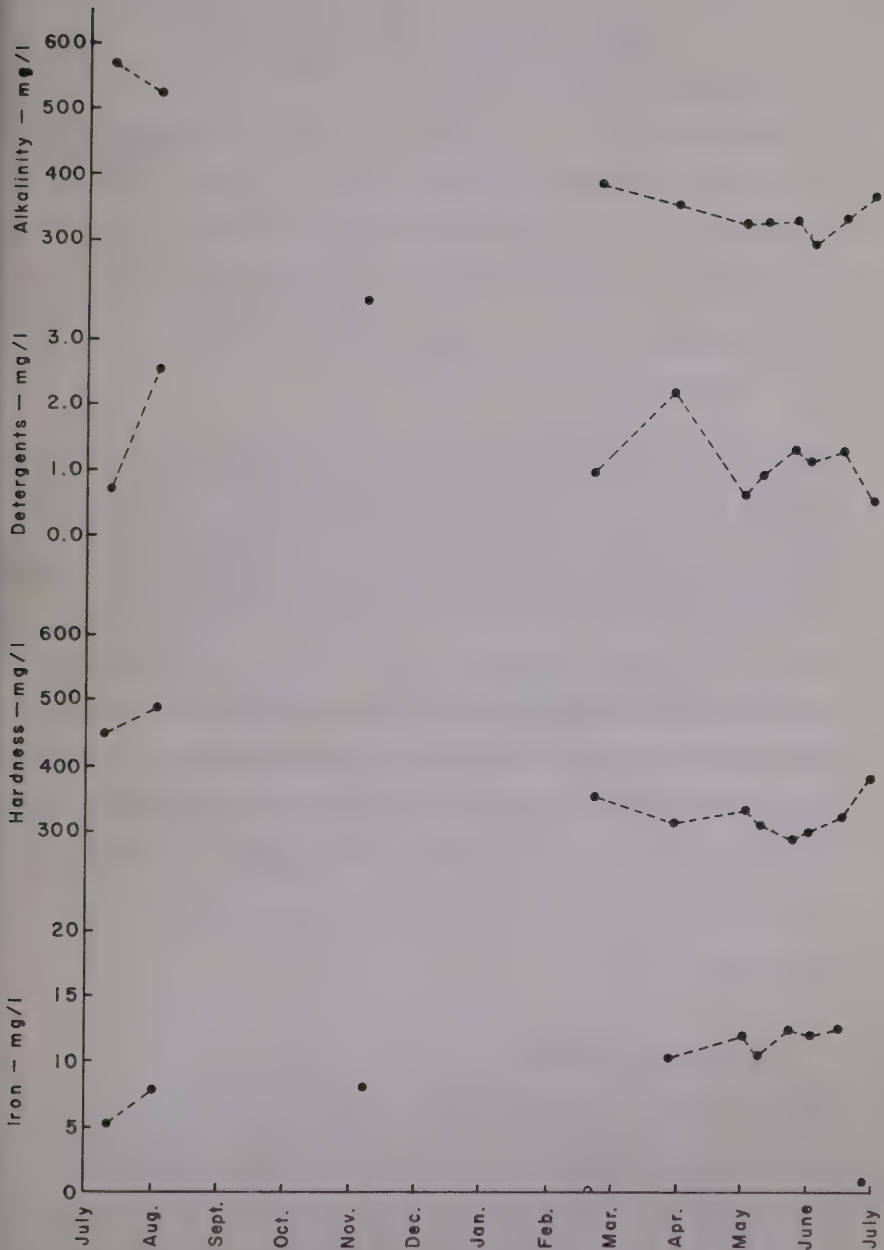

Figure 3 - Analytical data from House C.

Table 1 - Comparison of Average Well Water Quality of selected Houses in North Pole, Alaska with suggested maximum values - mg/l.

	A	B	C	D	Suggested Maximum Values
Iron	3.3	11.0	8.3	3.7	0.3
Detergent	0.6	1.2	1.5	0.07	0.5
Hardness	413	447	356	176	<100
Manganese	2.2	5.0	0.8	1.1	0.05

The dye used was Rhodamine "B", which has an affinity for organic material. It was felt that failure to recover the dye in the well water could be traced to absorption of the dye by organic matter present in the soil, or as a result of the dye passing between sampling points. It was therefore decided to use Rhodamine "WT", which is relatively unaffected by the presence of organics, and to drive a series of well points around a selected septic tank. Dye would be injected into the effluent of the tank and daily samples taken from the wells for fluorometric analysis. As the path of the effluent was defined, the well points would be removed and placed further along the suspected route. Water sample would also be obtained from spigots in the houses in the immediate area of the dye injection.

V. FLOOD OF AUGUST, 1967

Before the first set of well points could be driven, the Tanana Valley experienced its worst recorded flood. All areas which relied on septic tanks for sewage treatment and private wells for water supply were contaminated. The groundwaters of the area were literally saturated with contamination from sep-

tic tanks and surface water.

The original objective of the study, to trace shallow well contamination directly to septic tank effluent, was negated, because the whole area had now experienced some degree of contamination. The flood also prevented the recording of the area's groundwater table. The floodwaters floated the recorder out of position and weakened the retaining walls of the subterranean well house. The recorder was removed in the spring of 1968.

VI. CONCLUSION

The water quality data collected from North Pole prior to the flood revealed a water of poor quality (see Table 1). There were also indications of septic tank pollution in the consistent presence of LAS in the water, and an occasional positive coliform analysis.

On the basis of the findings in this study it will be recommended that the city consider a community water supply and distribution system. The poor quality of the groundwater and evidence of groundwater pollution from septic tanks in the area, make a community supply the only sound course of action for North Pole.

REFERENCES

1. "Public Health Service Drinking Water Standards," Public Health Service Publication No. 956, (1962).

2. Robeck, G. G., Bryant, A. R., and Woodward, R. S., "Influence of ABS on Coliform Movement Through Water-Saturated Sandy Soils," JAWWA Vol. 54, No. 1, pp. 75-82, January 1962.

3. Babbitt, H., Doland, J., and Cleasby, J., "Water Supply Engineering," McGraw-Hill Book Company, New York, pp. 392, (1962).

APPENDIX

HOUSE A

Date	Iron mg/1	Hardness mg/1	Alkalinity mg/1	Detergents mg/1	Colifor per 100r
7/11/66	4.4	424	417	1.80	0
8/02/66	2.6	419	419	.42	0
8/16/66	0.9	520	443	.56	0
8/29/66	2.3	442	429	.30	0
9/06/66	0.6	436	416	.30	0
9/26/66	3.9	418	402	.30	--
10/10/66	4.0	440	392	.50	--
11/7/66	3.8	--	--	2.40	--
1/25/67	3.6	440	366	.54	0
2/21/67	0.1	430	411	.43	--
3/14/67	2.1	380	398	.46	--
3/28/67	4.1	486	402	.40	0
4/04/67	1.9	450	398	.46	0
4/11/67	3.0	427	396	.36	--
4/19/67	5.4	--	389	.33	0
5/09/67	6.4	422	386	.47	--
5/23/67	5.8	409	385	.30	0
7/20/67	4.0	380	351	.19	0
MEAN	3.3	413	400	.60	--

HOUSE B

Date	Iron mg/1	Hardness mg/1	Alkalinity mg/1	Detergents mg/1	Colifor per 100r
7/11/66	5.0	460	533	0.8	0
8/02/66	9.2	546	522	1.8	0
8/16/66	1.3	525	571	2.4	0
9/26/66	5.0	504	593	1.5	0
10/10/66	10.4	513	573	1.5	--
11/7/66	9.1	--	--	2.8	0
2/21/67	0.1	434	471	0.1	0
3/28/67	10.0	458	443	1.0	0
4/04/67	2.2	404	430	1.2	--
5/02/67	15.5	344	373	0.9	4.5
5/16/67	18.0	379	414	1.1	--
5/23/67	17.4	409	460	1.2	0
6/07/67	22.0	448	455	--	--
7/05/67	22.5	516	440	0.8	--
7/12/67	17.0	404	433	0.8	3.6
7/20/67	40.0	452	490	0.5	10.0
MEAN	11.0	447	516	1.2	--

HOUSE C

Date	Iron mg/l	Hardness mg/l	Alkalinity mg/l	Detergents mg/l	Coliform per 100ml
7/11/66	5.0	446	566	0.7	1
8/02/66	7.7	487	530	2.5	0
11/7/66	8.4	---	---	3.6	---
2/21/67	0.1	357	394	1.0	---
3/28/67	10.4	319	363	2.2	---
5/02/67	11.8	331	334	0.7	0.5
5/09/67	10.4	310	335	1.0	0
5/23/67	12.2	293	337	1.4	---
6/01/67	12.0	301	308	1.2	0
6/15/67	12.5	327	342	1.4	---
6/28/67	0.5	388	382	0.6	0
MEAN	8.3	356	389	1.5	---

HOUSE D

Date	Iron mg/l	Hardness mg/l	Alkalinity mg/l	Detergents mg/l	Coliform per 100ml
8/23/66	3.7	171	162	---	0
9/19/66	3.0	171	153	.10	0
10/4/66	3.0	68	156	.20	0
2/21/67	0.2	163	134	.06	0
3/14/67	0.3	134	131	.07	0
3/28/67	4.4	191	144	.05	0
4/04/67	0.1	184	118	.04	0
4/11/67	2.9	160	142	.04	0
4/19/67	3.6	193	166	.00	--
5/02/67	5.6	185	142	.14	0
5/09/67	6.4	185	142	.07	0
5/16/67	4.2	163	153	.10	0
5/23/67	4.6	160	150	.04	0
6/01/67	4.8	180	138	.01	0
6/07/67	5.7	320	164	---	0
6/15/67	4.0	193	155	.10	0
6/21/67	3.2	172	153	.05	0
6/28/67	4.2	194	151	.05	0
7/05/67	5.8	160	147	.05	0
MEAN	3.7	176	147	.07	0